MATRIX$_X$ Automated Testing Tool

Ann Patterson-Hine, Joel Henry

This research program has focused on developing tools and techniques that can automate the process of testing and troubleshooting complex control systems that are implemented using an autocoder. Significant increases in software complexity and sophistication have made software more difficult to test and troubleshoot. Historically, the cost of debugging has been the most time-consuming and expensive aspect of large-scale software development. In order to increase software production efficiency, many real-time systems and controllers are being implemented with the code generated by automatic code generators, such as the MATRIX$_X$ SystemBuild from Integrated Systems, Inc. and SIMULINK Real Time Workshop from The Mathworks, Inc.

The MATRIX$_X$ Automated Testing Tool (MATT) was developed at East Tennessee State University to aid in the verification of systems implemented in the MATRIX$_X$ environment. The tool targets automation of black box techniques such as critical value testing, random input testing, cyclic value testing, and floating-point accuracy testing. MATT supports automated testing of MATRIX$_X$ models, at the superblock level, through a user friendly interface for both the Solaris and Windows platforms. This tool provides powerful support for the generation of test matrices, launching of simulation, capturing simulation results, and analyzing these results. Graphing is supported, as well as the ability to save test data for later reuse and save simulation results for regression analysis. MATT can literally generate thousands of tests, simulate those tests, and capture results in minutes. More than 20 test types are provided in addition to the ability to import user-created test data. A user simply selects a MATRIX$_X$ model, chooses a superblock, selects the number of tests, selects the test type for each input variable, creates an input matrix, launches a simulation, and analyzes the results through MATT Results and Summary screens. Graphs are easily created as well by simply choosing the input or output variables to graph and creating the graph in MATT.

In an era of highly ambitious technological goals critically dependent on real-time software, well-planned and effective testing strategies based on automation are needed to meet these goals. The MATT tool supports specification of a set of test types, strategies for applying these test types, and automated support for testing real-time systems built using MATRIX$_X$.

Point of Contact: A. Patterson-Hine
(650) 604-4178
apatterson-hine@mail.arc.nasa.gov

Nanoelectronics Modeling

M. P. Anantram, Liu Yang, T. R. Govindan, Jie Han, Alexei Svizhenko

Nanoelectronics research at Ames encompasses topics in molecular devices and miniaturization of conventional semiconductor devices. The objective is to acquire the knowledge necessary to build future generations of computing devices and sensors to fulfill NASA's challenges in aerospace transport and space missions. There were three significant accomplishments in FY99. First, we modeled electron transport in capped carbon nanotubes and gleaned the effect of caps and defects on electron emission, which is important in the use of the nanotubes as probe tips and wires. Second, through modeling and analysis we related conductance to mechanical deformation of carbon nanotubes, which is important in the use of nanotubes as sensors. Third, we developed a simulator for quantum mechanical transport in semiconductor devices, which provides important capability to study future generations of ultrasmall devices. A brief description of each follows.

The large length-to-diameter ratio of carbon nanotubes makes them good candidates for molecular wires and field emitters, and for use in probe-tip applications where electron emission from the tip of the capped tube is important. The results show that transmission probability mimics the behavior of the electronic density of states at all energies except the localized energy levels of a polyhedral cap (figure 1). The close proximity of a substrate causes hybridization of the localized state. As a result, subtle quantum interference between various transmission paths gives

rise to antiresonances in the transmission probability, at energies of the localized states (figure 1). Our observations indicate that by appropriately engineering the location of defects, these antiresonances can be transformed to huge transmission resonances. This is especially useful because these resonances offer a way to obtain a large current density in a narrow energy window around the localized energy level.

A potential application of carbon nanotubes as sensors is exploiting the relationship between mechanical deformation and electronic properties of the tubes. Our work provides fundamental insights into this relationship by providing detailed answers for the band-gap variation with tensile and torsional strain as a function of nanotube chirality, diameter, and magnitude of strain. The electronic properties of a nanotube in equilibrium are determined by indices (n, m), which define the chirality and diameter. The significant results are that (1) the magnitude of slope of band gap versus strain has an almost universal behavior that depends only on the chiral angle, and (2) the sign of slope depends only on the value of (n – m) mod 3. Figure 2 demonstrates these results for the case of tensile strain. For example, (6,5) and (6,4) nanotubes have chiral angles close to each other but the slope of band gap versus strain has opposite signs.

As devices continue to be miniaturized, modeling tools based on quantum physics become increasingly important. The difficulty in building such a simulator lies in developing a set of physical approximations that enable solutions on available supercomputers. We have developed such a two-dimensional device simulator which solves the nonequilibrium Green's function equations and Poisson's equation self-consistently on a nonuniform spatial grid. Figure 3 shows the self-consistently calculated charge density for one such case. The simulation predicts the expected small electron density close to the gate (x = 0 nm) at the large potential barrier created by the gate oxide.

Point of Contact: M. Anantram
(650) 604-1852
anant@nas.nasa.gov

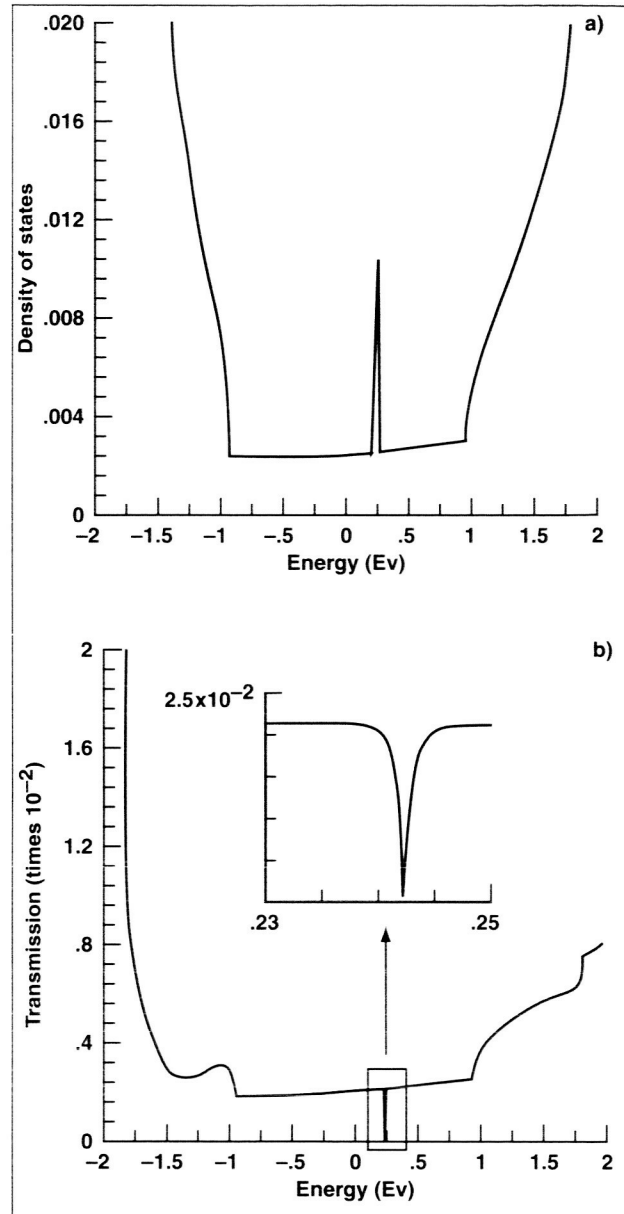

Fig. 1. (a) Density of states (DOS) versus energy in the cap region of a (10,10) nanotube with a polyhedral cap. The peak in DOS corresponds to localized energy levels in the cap. (b) The transmission antiresonances correspond to the DOS peaks in (a). The inset shows an expanded region of one antiresonance. In the presence of appropriate defects these transmission antiresonances are converted to resonances capable of carrying large currents when compared to the background energies.